Special Article

Curriculum development in anesthesia: basic theoretical principles

[L'élaboration d'un cursus en anesthésie : principes théoriques fondamentaux]

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Purpose: Educational theories provide a guiding basis for coherent medical curriculum development and instruction in a similar way that evidence-based medicine provides a rational basis for medical treatment. The purpose of this review is to provide general organizational, theoretical and educational principles for developing or modifying an anesthesia curriculum.

Source: This paper draws from the general educational and cognitive psychology literature, the medical educational literature from the period 1996–2006, as well as our experience in renewing the anesthesia clerkship curriculum at McMaster University.

Principal findings: Successful curriculum development includes the consideration of stakeholder needs, organizational issues, funding and sustainability, curriculum design, implementation and evaluation. Curriculum design includes the development of curricular goals and objectives, determination of the content and its organization, instructional methods and strategies, and assessment of the learners. Curriculum evaluation is used to judge the curriculum's merit and worth. The findings and recommendations from these evaluations feed back into the curriculum development cycle for further curricular improvements or modifications.

Conclusion: The current medical environment requires a responsive and efficacious curriculum that is able to keep up with its rapid pace of change. By providing a discussion of the educational and theoretical principles which underpin coherent curriculum development, this paper advocates a rational, theory-based approach to curriculum development.

***Objectif** : Les théories pédagogiques fournissent les principes directeurs de l'élaboration et de la mise en oeuvre cohérente d'un cursus médical de la même façon que la médecine factuelle sert de fondement au traitement médical. L'objectif de notre revue est de présenter les principes organisationnels, théoriques et éducatifs généraux de l'élaboration ou de la modification des cursus en anesthésie.*

***Source** : Nos sources viennent de la documentation générale sur l'éducation et la psychologie cognitive, les publications sur la formation médicale pour la période 1996 – 2006 et notre expérience du renouvellement du programme de stage en anesthésie à l'université McMaster.*

***Constatations principales** : Le succès de l'élaboration d'un cursus repose sur le fait de tenir compte des besoins des participants, des questions d'organisation, du financement et de la pérennité, du plan du programme, de son implantation et de son évaluation. La conception d'un cursus comprend la définition de buts et d'objectifs, la détermination du contenu et son organisation, les méthodes et les stratégies pédagogiques ainsi que l'évaluation des étudiants. L'évaluation du cursus permet de juger de sa valeur et de son bien-fondé. Les résultats de ces évaluations et les recommandations qui en découlent vont permettre d'améliorer ou de modifier le cursus par la suite.*

***Conclusion** : L'environnement médical actuel exige un cursus adapté et efficace qui peut suivre le rythme rapide des changements. L'analyse des principes éducatifs et théoriques nous amène à préconiser une approche objective de l'élaboration d'un cursus cohérent fondée sur la théorie.*

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Funding: Self-funded.

Accepted for publication March 27, 2006.

Revision accepted May 24, 2006.

Conflict of interest: None.

This article is accompanied by an editorial. Please see Can J Anesth 2006; 53: 855–7.

MEDICAL education has had to adapt to a number of challenges in past decades, including an exponential growth in medical information and technology, changing patient demographics and hospital practices, a decline in human resources, as well as increasingly complex ethical and medicolegal issues.[1,2] Developing a curriculum that reflects the dynamics of a changing medical environment while maintaining a sound learning experience can be a difficult task. The purpose of this article is to provide general organizational, theoretical and educational principles for developing or modifying a medical curriculum.

Clinical educators in medicine often base educational decisions on their considerable clinical and practical experience, intuition, personal preferences or "what worked for them". While this has been generally successful, this article argues that in order to further advance medical education, its practice needs to be better informed by the educational research literature. Recently, there has been a call to move from "opinion-based" medical education to "best evidence-based medical education".[3] The ultimate relationship of medical education to healthcare, the current climate of competency-based curriculum and the need for quality, cost effectiveness and accountability in an era of decreased resources provide some of the impetus behind this move.[4] There is a gap between the vast literature in educational research and its actual implementation in practice.[3] Although some have argued that evidence for the utility of educational theories has thus far been weak, others argue that progress in "best evidence medical education" has been impeded precisely because theory has been inadequately used to guide research and practice.[3–6]

In a similar way that evidence-based medicine provides a rational basis for medical treatment, sound educational theories provide a guiding basis for rational and coherent curriculum development and instruction. Moreover, a coherently developed curriculum is more likely to be effective and amenable to appropriate evaluation and modification.[7] For this reason, this article adopts a theoretical and conceptual approach, rather than a "how-to-do it" approach to curriculum development. Good illustrative examples of curriculum development in medical education can be found in articles by Wiers *et al.*,[8] Newble *et al.*,[9] and Kalet *et al.*[10]

For successful implementation, educators need to be mindful of the organizational and practical considerations associated with curriculum development. For instance, one of the first obstacles that curriculum developers will encounter is resistance to change. Resistance may result from a number of reasons, including inertia ("if it has worked for years, why change?" argument), lack of evidence for educational efficacy, prohibitive cost and logistics of implementing change, and the lack of personnel for implementation.[11] Furthermore, curriculum development must also include a process of continual program evaluation and amelioration as well as a succession plan for sustainability when the developers of the original curriculum design move on.[7]

At McMaster University, we recently redesigned the McMaster anesthesia clerkship curriculum (MACC) in response to some of the changing realities of the current medical environment. Changes to our curriculum included the incorporation of a week of "simulation-based" teaching, in addition to the preexisting week of operating room-based instruction. In addition to highlighting our experiences of curriculum development at McMaster University, a review of relevant publications from the medical, educational, and cognitive psychology literature was undertaken. A multidisciplinary strategy was taken for the literature review. First, a search of the general education literature was undertaken through the library catalogues of the University of Toronto and McMaster University for material pertaining to curriculum and instructional design, medical education and cognitive psychology. This was supplemented by a general MEDLINE search between the years 1996–2006 using the keywords: curriculum design, curriculum development, course design, instructional design and teaching and learning. A similar online search was conducted within the journal databases of Medical Education, Academic Medicine, Teaching and Learning in Medicine, Medical Teacher, Anesthesiology, the Canadian Journal of Anesthesia and Anesthesia and Analgesia. Supplemental articles pertaining to specific aspects of curriculum development were searched through their relevant keywords.

This review will first outline general organizational considerations associated with curriculum change. It will then focus on specific elements of curriculum design and development, including the development of goals and objectives at the program level. Different educational theoretical frameworks that form the foundation of curriculum design will be considered. Finally, assessment of learning and curriculum evaluation will be discussed. While the examples provided in this review refer to the undergraduate level, the general principles of curriculum development can be applied to educational programs at any level of training.

Definitions

The word, *curriculum*, derives from the Latin word for "racecourse". There are over 100 definitions of

curriculum in the professional literature.[12] It has been used to refer to a "course of study", "all of the planned learning experiences of a school" or a "structured series of learning outcomes".[12,13] For the purposes of this article, the *curriculum* is defined as the "subject content, skills, attitudes and values that make up an educational program".[14]

Curriculum development is a comprehensive term that includes the processes of curriculum design, implementation and evaluation.[15] *Curriculum design* refers to the specific processes involved in defining the content of what should be learned and how it should be organized.[13]

In the educational literature, a distinction is made between *curriculum* and *instruction*.[14,15] *Curriculum* is the content or the "what to teach" while *instruction* is the method. or the "how to teach".[15,16] In this conceptualization, curriculum design precedes instructional design.[14,15] However, other authors believe that this curriculum-instruction dichotomy to be unnecessary and artificial.[12] This article will distinguish between the two for conceptual clarity, although, in practice in designing MACC, we subsumed instructional design under curriculum design.

Although *assessment* and *evaluation* are often used interchangeably, this article will distinguish between the two. The term, *assessment*, will be used to refer to the appraisal of learners, and the term, *evaluation*, will be used to refer to appraisal of the curriculum.[12,15,17]

Preliminary considerations: organizational

The precipitants for curricular change can include, amongst others, the threat of loss of accreditation, poor course evaluations from the learners, teachers (or both) or recognition that the curriculum has not kept up with the current educational environment. Therefore, the first step in curriculum change is problem identification and demonstration of the need for change. Kern *et al.*[18] suggest that this involves a thorough analysis of the current curricular approach as well an articulation of an ideal approach.

Before any curricular initiative is entertained, it must be ensured that appropriate resources, faculty, support personnel and funding are available. Funding and human resources constrain the scope of the changes that can be entertained. The plan for curricular development must also have the support of the main administrative bodies, such as the Dean and the Department Chair, as well as the rest of the faculty.[7]

A curriculum planning committee can be established to develop and coordinate the implementation of the curriculum. All members of the committee should have clearly established roles and responsibilities. The curriculum chair should ensure that committee meetings promote a positive, collaborative working environment and efficient use of faculty time.

A needs assessment from all of the identified stakeholders in the curriculum is a necessary preparatory step for curriculum development. Input from the learners, teachers, administrators and support staff helps ensure that the resultant curriculum is responsive and reflective of the needs of those whom it is supposed to serve. This step also helps identify the scope of the administrative and organizational impact of curricular change. Information for a needs assessment can be obtained from questionnaires, surveys, interviews, focus groups, faculty retreats as well as literature reviews and consultations with other programs or educational experts.[7]

The results of the needs assessment can be used to help the committee in curriculum decision-making such as setting the goals and objectives for the anesthesia clerkship. This phase of curriculum development has been called deliberation, defined as "a decision-making process in which people…conceive a problem, create and weigh likely alternative solutions to it, envision the probable results of each alternative and select …the best course of action".[19] Alternatively, the committee could make use of formalized group solving procedures such as the Delphi Technique and the Nominal Group Technique.[20,21]

Once the curriculum design has been completed, there must be a plan for implementation and evaluation of the curriculum. It is also useful to "pilot test" part or all of the new curriculum before full implementation is undertaken in order to assess its feasibility, and make appropriate modifications.[18] There should be a plan for communication of the new curriculum to all of the stakeholders, as well as plans for faculty development and support for implementation of the new curriculum.

The curriculum planning committee should also take into consideration a "change management plan" in order to make sure the curriculum is sustainable even without the original designers. There are many curricular designs or innovative programs that have been implemented by a few dedicated individuals which simply fail when these individuals move on, because the program's success depended on them.[7] Sustainability of curricular change is positively influenced by several factors: the presence of institutional and opinion leaders with a clearly articulated vision and ability to involve faculty members, adequate resources and protected time, broad faculty ownership of the curriculum with ample opportunity to participate in, and influence the process, and a broadened

academic culture that views teaching and educational innovation as being an integral and important part of the institutional mission.[11]

At McMaster University, the precipitants for curricular change included clerkship evaluations that identified inadequacies in learning opportunities during the previous one week clerkship rotation. Similar concerns were expressed by faculty at departmental meetings and in a needs assessment survey. Discussions for curricular change ensued, which involved departmental faculty members, anesthesia residents, and the Departmental Chair. A simulation workshop for medical students was developed and piloted to assess its feasibility for incorporation into the new curriculum. Educational, resource and organizational and support issues were clarified at the administrative level before the decision was undertaken to proceed with curricular change. Curriculum development took place over a six-month period. Input and feedback from department members and residents was solicited during the process through both formal presentations and informal channels.

Models of curriculum development

The four main elements of curriculum development are: the content and organization (the curriculum design), teaching and learning strategies (instructional design), a process for assessing the learners (assessment) and a process for curriculum evaluation (evaluation).[13,15] There are a number of curriculum models, broadly categorized as either prescriptive or descriptive, which have been advocated to aid the process of curriculum development.[12,13,15] Prescriptive models suggest how curriculum development should proceed in a stepwise fashion whereas descriptive models describe what the process of curriculum development involves.[13] Descriptive models, as exemplified by Joseph Schwab's approach and Decker Walker's naturalistic model, emphasize the need for deliberation and consideration of the interplay of context, learner, teacher and subject matter in curriculum development.[12,19]

The prescriptive model is exemplified by Tyler's objectives model. First described in 1949, Tyler's model has remained very influential in curriculum development, despite criticisms that it reduces learning into a narrow set of behavioural objectives, and its disregard of contextual and situational factors.[12,18] According to Tyler,[22] four basic questions needed to be covered in curriculum development:

1. What educational purposes should the school seek to attain?
2. What educational experiences can be provided that are likely to attain these purposes?
3. How can these educational experiences be organized effectively?
4. How can we determine whether these purposes are being attained?

The first question is the most critical because specification of the end goals or objectives of the curriculum are the basis upon which learning experiences are selected, organized and assessed.[13] Evaluation of the curriculum is based on how well the learning objectives have actually been achieved.

With the current emphasis on competency-based learning, the outcomes-based model of curriculum development has recently emerged as a modern relative of Tyler's model.[13,15,23] Similar to the Tylerian model, the outcomes-based model works in an ends-means fashion where the learning outcomes are first specified, then curriculum design proceeds backwards from these learning outcomes. Because both models refer to desired behavioural endpoints, it has been questioned whether there is a significant difference between the outcomes-based model and Tyler's objectives-based model.[24] Indeed, the terms *outcomes* and *objectives* have often been used interchangeably in the literature.[25] In contrast, Harden[25] distinguishes between learning outcomes as being "broad statements of what is achieved and assessed at the end of a course of study", and instructional objectives as being "specific and detailed statements of educational intent".

In the end, the distinction between objectives and outcomes is less important than how the objectives or outcomes are constructed. They must be defined in sufficiently broad terms to include the non-quantifiable aspects of learning, yet specific enough to provide clear guidance on the expected knowledge, skills and values to be acquired at the end of the course. Because of its simplicity and common utility, this paper will make use of the Tylerian model in the following discussion of the components of curriculum development.

Curriculum design: specifying goals and objectives

Goals are the statements of general purposes or aims of the educational program. They can also be seen as philosophical or value statements.[15,18] Objectives are derived from goals and represent the learning, or behavioural outcomes stated in specific measurable terms. In deciding on the goals of an anesthesia clerkship program, several questions need to be asked. Is the program intended to teach clinical clerks the basics of anesthesiology? Is its purpose to teach basic airway management and knowledge of the circulatory system

TABLE I Goals and objectives written at the curriculum and instructional level

Level	*Goal*	*Objective*
Curriculum	Students will acquire the basic knowledge and skills of airway and circulatory resuscitation	90% of the students will be able to demonstrate successful use of the bag mask technique by the end of the rotation
Instruction	The student will become familiar with basic airway management techniques	The student will be able to demonstrate successful use of the bag mask technique in maintaining a patent airway and adequate ventilation in an anesthetized patient

TABLE II Goals and airway objectives of MACC

Goals

1. Students will acquire the basic skills of airway and circulatory management
2. Students will gain an understanding of the clinical application of pharmacology and physiology in anesthesia
3. Students will gain an appreciation of the multifaceted discipline of anesthesia

Objectives (abbreviated—only airway objectives shown)

- Students will be able to demonstrate their knowledge of the basic principles of airway and respiratory management as outlined:
  - a. Airway anatomy, assessment and management
  - b. Indications for tracheal intubation and controlled ventilation
  - c. Criteria for extubation of the trachea
  - d. Oxygen delivery systems
  - e. Appropriate parameters of intraoperative ventilation
  - f. Measures of adequate ventilation
  - g. Causes and treatment of hypoxemia
  - h. Prevention and treatment of aspiration

- Students will be able to demonstrate the following airway skills:

  Basic airway management skills
  - a. Provide a patent airway by jaw thrust, chin lift, oropharyngeal airway
  - b. Provide adequate ventilation using the bag-mask technique

  Use of the LMA
  - a. Preparation and insertion of the appropriately-sized LMA

  Endotracheal Intubation
  - a. Proper preparation of the equipment used for tracheal intubation including the appropriately-sized endotracheal tube
  - b. Proper positioning the patient for direct laryngoscopy
  - c. Proper laryngoscopy technique and tracheal intubation with minimal assistance

LMA = laryngeal mask airway; MACC = McMaster anesthesia clerkship curriculum.

required of a generalist? Or is its purpose to balance both? How do the programmatic goals relate to the general goals of clerkship, to the mission statement and the goals of the medical school? Likewise, what specific objectives will need to be attained in order to fulfill these goals? How can they be constructed so that they are inclusive, achievable and measurable within the allotted time frame?

As mentioned previously, a distinction has been made in the educational literature between curriculum and instruction—a similar distinction has been made between curricular goals and objectives *vs* instructional goals and objectives. The former is written at the level of the program or learners as a collective; the latter is written at the level of the individual learner. Examples of goals and objectives written at both levels are presented in Table I. This distinction may be important for curricula developed at an institutional, regional or national level, however, at the programmatic level, we have found it more practical to use a combination of

the two in order to arrive at a statement of general curricular goals and specific instructional objectives. Table II provides an example of the overall goals as well as an example of the instructional airway objectives that were formulated for MACC.

The setting of goals and objectives is a critical step and as such, can be the most challenging part of curriculum development. As discussed previously, it should be informed by a needs assessment survey and stakeholder input, so that the curriculum goals and objectives adequately serve the needs of those who are affected by the curriculum. Several iterative cycles of specified goals and objectives are likely needed before a final set of goals and objectives is adopted.

Curriculum design: specifying the content, organization, instructional strategies and methods

Determination of the content of the curriculum follows directly from the specified goals and objectives.[18] In other words, curriculum developers need to consider what content is required to enable the student to achieve the objectives or outcomes. Decisions regarding what should be included and what should be excluded from the vast scope of information available in the field, are required. For example, the decision to include a section on regional anesthesia will depend on whether the goal is to teach clinical clerks the basic principles of applied physiology and pharmacology, or to teach them about the scope of anesthesia practice.

Once the content has been determined, the organization of the content will need to be planned. One option in the organization and sequencing of the content is to consider all components of the content to be independent of each other, and therefore no particular sequence is required so long as all of the material is covered.[26] More commonly, however, is the use of an organizational format predicated on the belief that certain patterns or sequences facilitate learning. For instance, Tyler believed in organizing learning experiences so that each learning experience builds upon the previous (vertical organization) as well as mutually reinforcing each other (horizontal organization).[12] Some of the ways in which the organization of topics may be sequenced are: according to how topics are conceptually and logically related, according to the empirics of inquiry (i.e., how knowledge is acquired and successively built upon), how the topics are procedurally utilized, or in the sequence that learners will encounter in real life.[27] In designing MACC, we sequenced the learning experiences based on conceptual relatedness and the belief that the effectiveness of clinical teaching would be enhanced by prior preparation in a simulated environment. The introductory sessions included general topics such as the roles of anesthesologists, the scope of practice of anesthesia, basic airway and circulatory support skills and principles of preoperative assessment and perioperative care. Subsequent sessions on applied physiology and pharmacology and intraoperative management are built on the concepts and skills acquired in the introductory sessions.

The choice of the type of instructional strategies and methods for the delivery of the content of the curriculum can be guided by educational theories. Educational theories, broadly categorized into behaviourist, cognitive, constructivist, and humanist approaches, provide theoretical guidance by describing the conditions and factors under which effective learning can be promoted.[28,29]

Each approach has a set of assumptions about what facilitates learning as well the nature of the teacher-learner relationship. The behaviourist approach views the learner as a passive recipient of information and focuses on behaviour as a learned response to stimulus.[30] This approach to curriculum design is directive, teacher-centred, and makes use of positive (or negative) reinforcement, such as frequent use of feedback and assessments, in order to bring about desired learning outcomes. The cognitive approach views the learner as an active processor of information and would focus on strategies that optimize the internal cognitive processes which underlie learning, such as information processing, memory representation, and problem solving.[31] The constructivist approach, such as Kolb's theory of experiential learning, views learning as an active construction of reality brought about by the learner's experiences. This approach would emphasize the importance of exposure to many experiential opportunities to enable learning through experiencing, reflection and active experimentation.[32] The humanist approach, such as Knowles'Adult Learning Theory, assumes that adult learners are naturally self-directed and internally motivated to learn.[29,33] A humanistic approach would take a learner-centred focus, negotiate individualized learning objectives, and make use of self-directed learning strategies and self assessment.

These different categories of educational theories are not mutually exclusive and it is not uncommon for curricula to make use of the tenets of more than one school. It is important that irrespective of which theories are chosen, that these be rationally applied to the curricular design in a manner that provides theoretical coherence for decision-making as well as consistency with the underlying philosophy of the curriculum.

Cognitive learning theories, with their empiric bases, have played a dominant influence in instruc-

tional and curricular design and will therefore be further detailed.[16] The work in cognitive psychology has revealed the central importance of memory in the processes involved in learning and knowledge acquisition.[34,35] It also has stressed the importance of deliberate practice and motivation in acquiring expertise.[36,37]

A curriculum that makes use of cognitive learning theories would incorporate educational strategies that are known to enhance memory processes, motivation and provide many opportunities for practice. Memory processes are enhanced by elaborative rehearsal and deep processing of information. Elaborative rehearsal enhances memory processes by expanding and connecting the meaning of the information to other concepts already in memory. Deep processing refers to thinking about the information in terms of their semantic meaning rather than their superficial characteristics.[34,35] Therefore, the curricular content should be presented in a manner that can be connected to, and elaborated upon by the learner's past experience and knowledge, supplemented by the use of many illustrative examples. Instructional strategies should be employed that promote active cognitive processing, such as the use of problem-based tutorials, student-led presentations and discussions of actual clinical cases, and hands-on practical workshops.

Another cognitively-based strategy is the enhancement of transfer appropriate processing. Transfer appropriate processing refers to the phenomenon where learners are more successful in retrieving information from memory if the conditions that are present at retrieval are similar to those present during learning.[34,35] For instance, if students had learned about the algorithm for the management of a difficult intubation in a didactic lecture, and were later asked to retrieve the information in a simulated clinical setting, their ability to retrieve the information may be impaired, because the conditions of retrieval were different from those originally present at informational processing. Therefore, to ensure that students perform optimally in a real-life clinical setting, the curriculum needs to provide opportunities for them to process information in the context and the format which will be required for retrieval in real life. Therefore, adequate opportunities for students to be involved in simulated and real clinical settings should be provided.

Motivation can be affected by many factors both intrinsic and extrinsic to the learner. While assessment has been one way of "inducing" motivation, more positive ways of enhancing motivation could involve incorporating multimedia technology and those teaching modalities of teaching which have been found to be enjoyable, engaging and interactive. For instance, problem-based learning has consistently been shown to be a more enjoyable mode of learning than traditional forms of instruction and may promote better problem solving skills.[9] Selecting modalities of teaching which lend themselves to the different cognitive and preferred learning styles of students may also contribute to improved learning and motivation.[38,39]

Instructional methods can range from lectures and demonstrations to problem-based learning and high fidelity simulations. Each method has its strengths and limitations, and like any tool, individual value is determined by how the method is used and in which context. For instance, lectures are an efficient means of teaching because of their low cost, ability to accommodate large numbers of learners and provide a structured learning environment.[18] Disadvantages of the lecture format are its inclination towards being a teacher-centred and passive form of learning. Problem-based learning encourages active learning, facilitates higher cognitive processes such as problem solving, and is student-centred. However, problem-based learning techniques require more time for development and delivery, more trained staff, and may be less efficient in transferring factual information. Teaching in the clinical setting is advantageous as new knowledge, and many skills, including problem-solving, decision-making, psychomotor and communication skills may be taught and learned. However, limitations include the opportunistic and unpredictable nature of clinical exposure, time pressure, and potential risks to the patient. Simulation, both low and high fidelity, provide safe environments for active learning, repeated practice and feedback. The main disadvantages of simulation in anesthesia include cost, labour-intensiveness, and indeterminate transferability to real life settings.

In designing MACC, we were primarily informed by the constructivist and cognitivist schools. This included the tenet that active experiential learning is most effective. Therefore, our curriculum aimed to provide many opportunities to engage students in active hands-on participation or problem solving exercises that emphasized understanding, application and synthesis of material rather than surface memorization of material. This included opportunities for practice in context-appropriate simulated and clinical settings. We also incorporated a variety of instructional methods in order to balance their respective advantages and disadvantages as well as to accommodate the potential different learning styles of the students. Lecture-style presentations were balanced by the use of interactive questions to engage the audience. Students engaged in problem-based small group sessions and student-led presentations as well as practical workshops with

part-task airway and *iv* arm simulators. A medium fidelity patient simulator in conjunction with a fully equipped simulated operating room setting was also used for practicing intraoperative scenarios.

Assessment of learners

Assessment serves the purpose of ascertaining whether the curricular content has been learned successfully. Assessment can be defined as summative (for "pass/fail" purposes) or formative (for learning purposes). Formative assessment can also be referred to as feedback.[40]

Assessment has been described as the engine that drives learning.[41,42] Students will typically study only the content upon which they will be tested, processing information (surface or deep approach) in the manner that best matches the retrieval requirements of the test or assessment method.[39]

Formative assessment or feedback is an integral part of developing expertise by shaping learning behaviour and practice.[36,37] It stimulates critical reflection and meta-cognitive skills.[40] Feedback is more effective if it is given with minimal delay.[37] Therefore, learners and teachers should be given ample opportunities for the provision of feedback. Because of these characteristics, assessment can be viewed as not only a means of ascertaining whether instruction has been successful, but as an instructional strategy itself. Therefore, assessment should be considered an essential part of curriculum design rather than simply a psychometric issue.[42]

In designing what types of assessment methods should be used, several considerations are important. First, assessment should be matched to the intended objectives and goals of the curriculum, a process called blueprinting.[41] That is, assessment should focus on what objectives, outcomes or competencies learners are expected to achieve. Assessment methods also need to be feasible from a practical and financial point of view.

It is also important to consider whether the purpose of assessment is formative or summative. Psychometric criteria of reliability, validity and the need for pass-fail standard setting become much more critical in summative assessment (particularly high stake assessments for licensing purposes) as opposed to formative assessment.[43] Reliability refers to the reproducibility of the findings of the assessment. A major factor that influences a test's reliability is adequate sampling of the learners' knowledge and abilities, which in turn is related to the length of the test.[41,42] This is partly related to the phenomenon of content-specificity where it has been determined that performance in solving a problem is specific to the content of that problem, and is not predictive of the ability to solve other types of problems.[44]

Validity refers to the ability of the assessment to actually measure what it purports to be measuring. An important aspect of ensuring validity relates to selecting the assessment methods which are appropriate to the specific level of competency. Miller[43] has described a pyramid model of competence, where the base of the model has been termed "basic factual knowledge" or "knows". The next levels are respectively, applied knowledge, or "knows how", and performance in a simulated situation or "shows how". The apex of the model is performance in the actual clinical setting or "does".[41,43] For example, if we are simply satisfied with students knowing the signs and symptoms of shock, we may test them with multiple choice question tests. However, if we want students to demonstrate if they can problem solve as well as initiate appropriate resuscitation (i.e., "knows how" and "shows how"), assessment will also need to include problem solving tasks, objective structured clinical examinations, simulations and assessments in the clinical setting.[41,43] Recently, van der Vleuten and Schuwirth[42] have suggested a more holistic approach to assessment, arguing that there is no assessment method that is inherently more valid or reliable than the other—it is a matter of the context and purpose for which it is utilized. In their view, then, a good assessment program is multimethod, using both qualitative and quantitative data, and broad sampling from many sources that cover competencies through Miller's pyramid.

We took these considerations in determining assessment methods. Important aspects of the rotation objectives included active participation in all of the teaching and clinical sessions, acquisition of knowledge and basic technical skills as well as demonstrating professionalism in all interpersonal interactions. The evaluation was based on daily evaluation of the medical student's performance in both the teaching sessions during the simulation week and daily clinical performance in the operating room. Knowledge base was assessed by a multiple choice question examination.

Evaluation of curriculum

Curriculum development is a cyclical iterative process which is informed and changed by curriculum evaluation (Figure). Curriculum or program evaluation has been defined as: "the systematic collection of information about the activities, characteristics and outcomes of programs to make judgments about the program, improve program effectiveness and/or to inform decisions about future programming".[45] The purposes of curriculum evaluation can vary widely from specifically determining whether the curriculum has achieved its prescribed goals and objectives (a criterial approach)

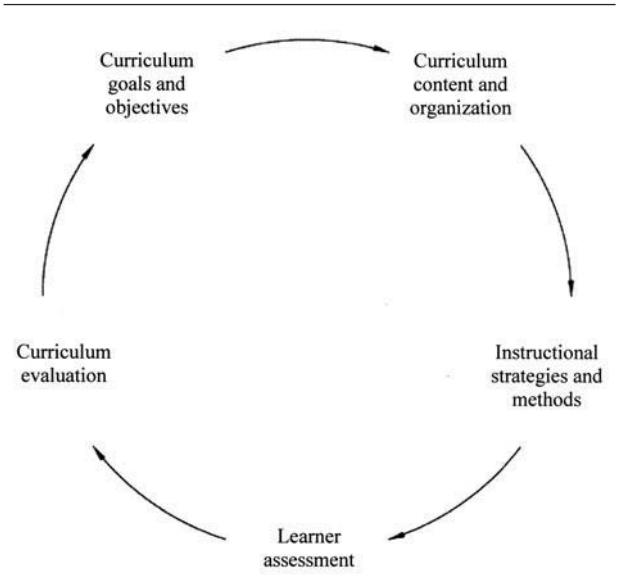

FIGURE Cycle of curriculum development.

to broader purposes such as whether the curriculum has satisfactorily served the needs of the different participants (issues-centred approach).[17] Depending on the purpose, the questions that form the focus of curriculum evaluation may include: Do the goals and objectives appropriately address the needs of the learners in the curriculum? Does the curriculum provide adequate opportunities for student learning? Does the curriculum lead to better learning outcomes compared with another? Does it lead to better patient outcomes? Is it cost-effective?[11,15,17]

Similar to assessment, evaluation can be either formative or summative. Formative curriculum evaluation can occur at any stage of development in order to improve its responsiveness; summative curriculum evaluation typically occurs when the curriculum has been implemented. In both, evaluation helps inform whether the curriculum is meeting the needs of the stakeholders as well as make recommendations for improvement. Summative evaluation can inform decision-making about the adoption or funding of a curriculum.

Program evaluators may be from within the program or outside of it. Jolly and Peyton[46] suggest a small steering committee which includes members of the curriculum development committee. This ensures that a sense of ownership of outcomes of the evaluation is retained rather than seen as "externally imposed". This steering committee can then make decisions as to the purpose(s) of curriculum evaluation, what should be evaluated, when to evaluate, and the choice of the appropriate methodologies. It can also decide how to analyze the results, to whom the results should be disseminated, and how suggestions for change can be implemented.[46]

There exist over 40 models of curriculum evaluation in the literature.[12] Similar to his curriculum model, Tyler advocated an ends-means, criterial approach to curriculum evaluation, where the purpose of evaluation was to determine whether the educational objectives have been achieved by the learners.[12,22] This model makes use of the comparison of pre- and post-instructional tests chosen on the basis of "sound" psychometric qualities. Other models using the criteria approach use various other comparative strategies such as quasi-experimental and randomized control trials. However, the criteria approach has been criticized for its narrow focus on attainment of pre-specified objectives, which leaves no room to evaluate the appropriateness of these objectives in the first place.

Other models take a more expansive perspective, focusing not only on learning achievements, but also on the roles of the teachers, learners, subject matter and the environment.[12] For instance, the "issues approach" forwarded by Stake[17] takes a more open ended, "responsive" rather than prescriptive approach to curriculum evaluation. In his model, Stake uses "issues" (that are defined as matters upon which people disagree) as starting points for evaluation.[17] The identification of issues results from the participation of all stakeholders. This pluralistic approach acknowledges the variety of perspectives which are incorporated in the evaluation of a curriculum, as well as the different ways in which the quality of a program may be defined.

Therefore, depending on the model of curriculum evaluation, and the questions that are asked, the methods employed for data gathering may be either quantitative or qualitative, or both.[17,47] For instance, measures of learner satisfaction may be obtained through questionnaires, rating scales or individual or group interviews. Measures of learning outcomes may be obtained from written or performance test results, direct observations, or different experimental designs (observational, quasi-experimental and random controlled trials).[18,46]

The activities associated with curriculum evaluation: description, comparison, and prediction, contribute to making value judgments on the merit and worth of a program.[47] As such, curriculum evaluation has to be seen as a disciplined and rigorous process with broad representation in order for its findings to be viewed as

credible, and contributing positively toward the goal of program improvement.[11]

Conclusion

This paper provides general theoretical educational principles to aid rational decision-making for undergraduate curriculum development. The current medical environment requires curriculum development that is responsive to optimizing learner needs and a rapidly advancing knowledge base. Curriculum development is an iterative, cyclical process that is at once rigorous and creative. Curriculum developers must consider the needs of all stakeholders in order to ensure that the curriculum is responsive to those whom it was designed to serve. Careful attention must be paid to the main components, including the goals and objectives of the curriculum, the content and its organization, instructional methods and strategies, assessment of learners, and curriculum evaluation. Finally, organizational considerations such as ensuring adequate funding, administrative support, broad faculty ownership, implementation and sustainability planning are necessary for the success of any curricular renewal. Although development of best-evidence medical education is still being defined, this process can be aided by the use of "theory-based" medical education.

Acknowledgements

The significant contributions which Drs. Rob Whyte and Greg Peachey have made to the McMaster Anesthesia Clerkship Curriculum are acknowledged with great thanks. Dr. Norm Buckley's support of the process of curriculum development at McMaster University is greatly appreciated.

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